ZJU-UIUC Institute
ME470/ECE445
Senior Design Proposal

Continuous Roll-To-Roll LB Film Deposition Machine

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1. Introduction

1.1 Problem

The application of Langmuir-Blodgett (LB) coating technology has significantly enhanced the performance of material surfaces. Its precise control over molecular layers enables researchers to design and fabricate more complex and efficient nanomaterials, thereby advancing the fields of material science and nanotechnology. However, traditional LB coating techniques face challenges with low production efficiency and limitations in scaling up for large-area manufacturing.

1.2 Solution

Develop an instrument based on Langmuir-Blodgett (LB) coating technology, utilizing a Roll-To-Roll dual-roller structure to achieve sustainable production of nanofilms. This method can significantly enhance the production efficiency and quality of LB films, contributing greatly to their widespread industrial application. By enabling continuous production, this project aims to overcome the issues of low efficiency and difficult quality control encountered in traditional LB film production, thereby paving new pathways for the commercialization and practical application of LB films.

1.3 Visual Aid

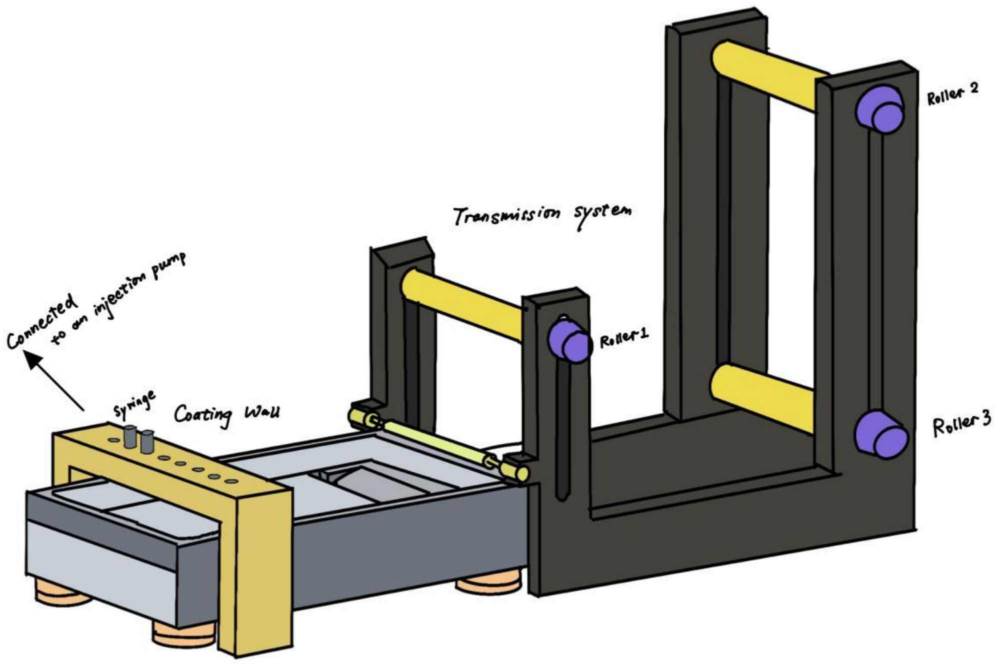


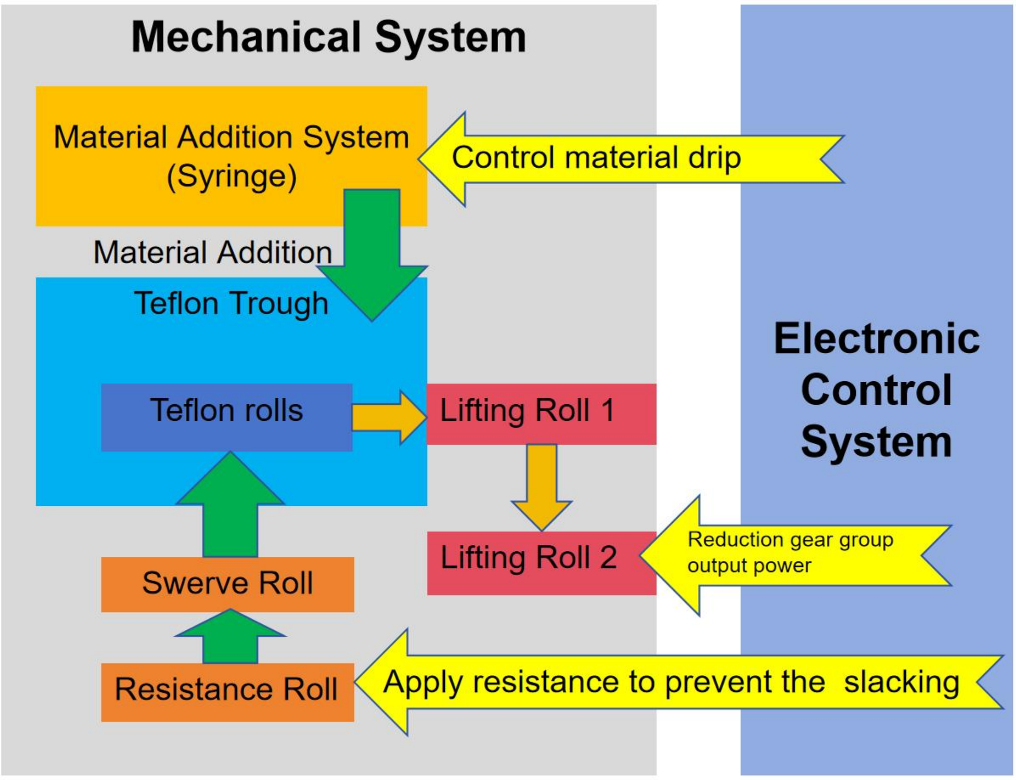
Figure1. Detail Design Sketch

1.4 High Level Requirement List

High Level Requirement	Description
The efficiency of material self-spreading	The ability for materials to evenly spread on a substrate is essential for producing uniform films with desired functionalities. Effective self-spreading ensures the film's uniformity, impacting its performance across various applications. Utilizing techniques like moving water can aid in achieving better distribution and quality.
Ensuring that the material does not penetrate the film from both sides	Ensuring that material does not breach the film from both sides is crucial for maintaining the film's integrity and performance. Strategies to prevent penetration are vital, including chemical modifications or optimizing coating processes, to produce high-quality films suitable for precision applications.
Observing the quality of the film during the deposition process	The capability to monitor film quality in real-time during deposition enhances production efficiency and quality. Employing UV light or special inks for instant quality assessment allows for adjustments on-the-fly, reducing defects and supporting the development of new materials.

2. Design

2.1 Block Diagram



2.2Subsystem Overview

The design of this product is mainly divided into two major systems: mechanical control system and electronic control system. The mechanical system includes reel lifting subsystem and material injection subsystem. The electronic control system includes image capture subsystem and stepper motor control subsystem.

2.3Subsystem Requirements

2.3.1 Mechanical System

The project consists of three parts: 1.The production system, including stainless steel tanks, is used for loading liquid solvents on which nanomaterials float. Above one side of the slot is a nanomaterial burette for adding nanomaterial to the slot, which is controlled by a computer system. 2.The collection system consists of a bracket and five stainless steel rolls, two of which are used to collect Ptes with nanomaterials attached to the surface and three of which are used to adjust the slope of the contact area. The reel is connected to the transmission and motor and is controlled by a computer system. 3.Electromechanical control system with all computer components built in, used to adjust the traditional speed, find the best production conditions, control the operation of the system.

2.3.2 Electronic Control System

A picture of the 1-D LB film formed on the water surface using a microscope is provided to the user interface subsystem. Real-time slicing provides users with real-time histograms that reflect particle density and orientation. The analysis part outputs the analyzed motor motion instructions to the computer control system. The control system converts the instructions we want the motor to perform into specific signals and inputs them into the motor.

2.4 Tolerance Analysis

The main load affecting the work of the product comes from the tension between the first drum and the last drum, we need to ensure that there is enough power to drive the overall movement, while increasing the resistance on the first drum, so that the roll is always tight, you can ensure that the plane moving speed and the motor output speed is completely consistent. The output power of the motor is reached by a reduction gear set of 1:1000, the output power of 5W, and the resistance added to the first drum is estimated at 10-20N.

3. Ethics and Safety

In the subsequent experiments of our project, considering ethics and safety as paramount, we implemented a series of measures to ensure the safety of the experimental process and responsibility towards the environment. Specifically, in the experiment where thermoelectric cooling plates and water-cooling blocks were introduced to control the temperature at the bottom of the PTFE trough, we meticulously designed a real-time monitoring system. This system allows for the precise control and continuous monitoring of the temperature in the coating well, ensuring that experiments are conducted within a safe temperature range. Additionally, we conducted rigorous safety training for laboratory personnel, ensuring they are familiar with the safe operation procedures for all equipment and can respond quickly in emergency situations. We also took into consideration environmental protection and energy efficiency, ensuring that the materials and technologies used are both efficient and eco-friendly. Through these comprehensive measures, our project not only maintains high standards of ethics and safety in exploring scientific questions but also demonstrates our commitment to environmental responsibility and the safety of laboratory personnel.